# STUDY ON THE PERFORMANCE AND EMISSION CHARACTERISTICS USING CASTOR AND MUSTARD SEED OIL MIXTURE AND DIESEL BLEND IN C.I ENGINE

**Gaurav Shukla[1], Atul Jain[2],**

[1]*Assistant Professor Department of Mechanical Engineering R.B.S. Engineering Technical Campus Agra, (U.P.), India*

[2]*Assistant Professor Department of Mechanical Engineering R.B.S. Engineering Technical Campus Agra, (U.P.), India*

---

**Abstract -** *Bio-diesel is one of the most promising alternatives for diesel needs. The present work has focused on the performance of castor non-edible vegetable oil and Mustard oil edible vegetable oil and its blend with diesel on a double cylinder, 4 stroke, naturally aspirated, direct injection, water cooled, eddy current dynamometer Kirloskar Diesel Engine at 1500 rpm for variable loads. Initially, castor eats oil and their blends were chosen. The physical and chemical properties of Castor oil, Mustard oil and its blend were determined. In general, viscosity of neat vegetable oil is high, which can be reduced through blending with diesel and heating them. The performance and emission characteristics of engine are determined using Castor and Mustard oil and their blends with diesel. These results are compared to those of pure diesel. By analyzing the graphs, it was observed that the performance characteristics are reduced and emission characteristics are increased at the rated load compared to those of diesel. This is mainly due to lower calorific value, high viscosity and delayed combustion process. From the critical analysis of graphs, it can be observed that 10% of Castor oil and Mustard oil mixture mixed with 90% of diesel is the best suited blend for Diesel engine without eating and without any engine modifications. It is concluded that castor and Mustard oil can be used as an alternate to diesel.*

***Key word – Kirloskar diesel engine mustard and castor oil***

## 1. INTRODUCTION

India is one of the fastest developing countries in the world with a stable economic growth, which multiplies the demand for petroleum fuels manifold. It was reported that in the year 2011, India was the fourth largest energy consumer in the world after the United States, China, and Russia [42]. To meet the ever growing energy requirement, it depends mainly on imported crude oil due to lack of fossil fuel reserves, and this has a great impact on the economy. Therefore, India has to consistently look for an alternative to meet the future energy demand. Various alternative fuels for diesel engines have been explored by many researchers over the past few decades [13]. In many countries, agricultural land is abundantly available where biodiesel can be produced at low cost. Biodiesel is a fuel composed of mono-alkaline esters of long chain fatty acids that are obtained from triglycerides such as vegetable oil, animal factor algae. Numerous research works have been documented in the past on the utilization of biodiesel in compression ignition (CI) engines, both stationary and mobile .It can be directly used as a fuel in diesel engines without any major engine modification, and it gives almost equal fuel efficiency and lower particulate emission compared to conventional diesel. The demerits of a biodiesel fueled engine include issues of poor cold flow properties, higher viscosity and higher emission of nitrogen oxides compared to a diesel fueled engine. Energy comes in a variety of renewable forms; wood, biomass, wind, sunlight. It also comes in the non renewable form of fossil fuels- oil and coal and their use is a major source of pollution of land, sea and above all the air we breathe. Two centuries of unprecedented industrialization, driven mainly by fossil fuels, have changed the face of this planet. The present civilization can’t survive without motor cars and electricity. The increasing rate at which the changes in human lives are occurring has important consequences for the environment and carrying capacity of earth. The industrial revolution has brought greatly increased wealth to one quarter of the population and severe inequalities. Pollution and accelerating energy consumption has already affected 10.

### 1.1 LITERATURE REVIEW

#### Economics

The primary factors affecting the economics of biodiesel include the purchase price and the quality of feedstock (Piazza, 2007) [12].

Raw materials for fuel production, such as soybean oil, cottonseed oil, renderings, and waste oil each carry a purchase price based on feedstock quantity and geographic availability, competition with other uses of the feedstock, and product quality (Capareda, 2007)[4].

## Engine Performance

Alternative fuel use can only be considered feasible alternatives if engine performance is maintained when using alternative fuels and fuel blends. Three points of interest when determining engine performance are brake effective power (BEP), brake-specific fuel consumption (BSFC), and thermal efficiency

**Cetinkaya et al. (2005)[5]** Observed that the reduction of torque was only three to five percent when comparing waste oil biodiesel to petroleum diesel in a 75 kW four-cylinder common rail engine. **Lin et al., (2006)[23]** found that the power at full load when using pure palm oil biodiesel was only 3.5% less than that of petroleum diesel in a 2.84 L naturally aspirated engine.

When using a 70% tall oil biodiesel blend, **Altiparmak et al. (2007) [2]** measured a 6.1% increase in maximum torque. **Usta (2005) [15]** observe increases in torque and power when fueling an indirect injection diesel engine with tobacco seed oil biodiesel blends.

**Yucesu and Ilkilic (2006)[16]** observed that the heating value for cottonseed oil (CSO) biodiesel was only five percent less than the heating value of petroleum diesel. They observed power and torque reductions of three to eight percent when using pure CSO biodiesel.

According to **Lapuerta et al. (2007) [7]**, "thermal efficiency is the ratio between power output and energy introduced through fuel injection." Most authors observed no significant change in thermal efficiency when using biodiesel. Some of those authors include **Lapuerta et al. (2007) [6], Canakci (2005) [3], and Monyem et al. (2001) [9].**

## Exhaust Emissions

According to the National Biodiesel Board (2006) [10], biodiesel is a clean burning alternative fuel produced from domestic, renewable resources, such as plant oils or animal fats. While bio-diesel contains no petroleum, it can be blended with petroleum diesel to create a fuel suitable for use in diesel engines. It is important to understand the relationship between biodiesel blends and exhaust emissions

**Munoz et al (2004) [8]** found that the concentration of carbon monoxide (CO) in the exhaust decreased, except at high speed and load, while hydrocarbon emissions (THC) reduced at low loads, and NOx emissions depended on the speed and load of the engine when petroleum diesel was replaced with biodiesel mixtures.

**Altin et al. (2001) [1]** evaluated the performance and exhaust emissions of a diesel engine using 100% refined vegetable oil and their biodiesel. The authors concluded that biodiesel gave performance and emission characteristics closer to the diesel fuel.

**Zhu et al. (2010) [17]** compare the performance and emissions of a diesel engine fuelled with biodiesel blended with different ratios of ethanol and methanol, and to compare this result with those obtained with pure biodiesel and Euro V diesel fuel, under different engine loads. They demonstrated that, a slight increase in brake thermal efficiency for the 5% blended fuels, for both the methanol and ethanol blends.

**Pramanik (2003) [11]** evaluated the engine performance using the prepared Jatropha blends as fuel. The author reported that significant improvement in engine performance was observed

"We're going to be using our oil late this year," said Hunter Horvath, assistant general manager of the transit agency. The timing depends on when the seed can be pressed and refined. Presses are in short supply this time of year because the wine grape crush is under way, he said. The mustard seed experiment began in February on 20 acres owned by San Bernabe Vineyards near King City. Pacific gold and wild California mustards were planted to determine which variety of the plant would produce the most seed oil.The idea is to determine whether mustard could be a sustainable, home-grown substitute for corn and soy, the primary sources of biodiesel fuel. Buses on the Monterey-Salinas Transit line already burn fuel with 20 percent biodiesel from soy beans, Horvath said of the two varieties, only the Pacific gold was harvested because turnips overran the other field, making it impossible to use a combine to collect the wild California seed, Horvath said. The ton and a half of seed will produce about 750 to 800 gallons of biodiesel. Like other biodiesel, the mustard oil will constitute 20 percent of the fuel mixture that powers the buses, he said.

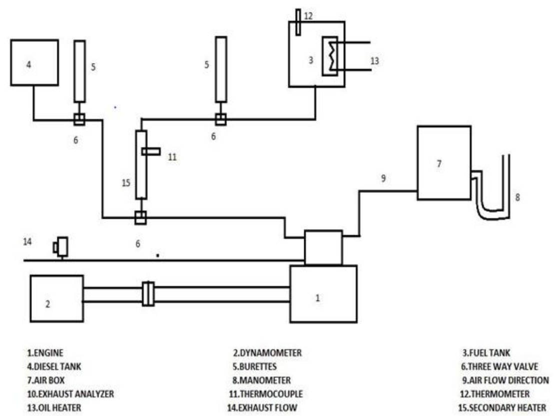
| S. No. | Properties | Diesel | Mustard Oil |
|---|---|---|---|
| 1 | Specific gravity | 0.83 | 0.672 |
| 2 | Calorific value | 43.22 | 42.11 |
| 3 | Flash point | 47 | 518 |
| 4 | Viscosity | 5.5 | 33.8 |
| 5 | Sulphur content | 10 | 170 |
| 6 | Acid value | 0 | 1.5 |
| 7 | Fire point | 64 | 90 |
| 8 | Cetane number | 49 | 47 |

**Table: 1: Shows the comparison of properties of Mustard Oil with Diesel**

| S. No. | Properties | Castor Oil | Mustard Oil | Mixture Oil | Diesel |
|---|---|---|---|---|---|
| 1 | Specific gravity | 0.96 | 0.672 | 0.816 | 0.83 |
| 2 | Calorific value | 36.2 | 42.1 | 37.85 | 43.22 |
| 3 | Flash point | 317 | 518 | 417.5 | 47 |
| 4 | Viscosity | 226.82 | 33.8 | 130.31 | 5.8 |
| 5 | Sulphur content | 20 | 170.5 | 95.25 | 10 |
| 6 | Acid value | 1.642 | 1.5 | 1.57 | 0 |
| 7 | Fire point | 345 | 90 | 217.5 | 64 |
| 8 | Cetane number | 40 | 47 | 43.5 | 49 |

**Table 2: Properties of Castor and Mustard Seed Oil Mixture and Diesel**

## 1.2 Experimental Setup & Procedure




## 1.2 Engine specification

| | |
|---|---|
| ENGINE | 4S TWIN CYLINDER, WATER COOLED, DIRECT INJECTING, VERTICAL, 3.7 KW POWER |
| MAKE/MODEL | KIRLOSKAR TV 1 |
| BHP AND RPM | 12 BHP @1600 RPM |
| BORE*STROKE | 78MM*115MM |
| COMPRESSION RATIO | 16.5:1 |

**Table 3: Engine specification**

## 1.3 Procedure

The castor oil and mustard oil are mixed together to prepare a mixtur*e. The proportion of mixing the two oils are 50% and 50%.then 10% of the mixture is taken and* 90% of diesel is taken to prepare the blend. This is the first fuel to be tested. Then 20% of the mixture is taken and 80%diesel is mixed to prepare the second blending likewise 30% blend is taken and tested.

The blend oil is put in the fuel tank, the engine is started first we have to take the reading for 0 load and time taken to consume 20ml of oil is noted down. Afterwards load is increased gradually as 0, 5,10,15,20 and 25Kg.

| Sr. No. | Load (Kgf) | Engine Speed (Rpm) | Time (Sec.) | Ex. Temp. (°C) | Fuel Consumption (Kg/Hr.) | Brake Power (KW) | Brake Sp. Fuel Consumption (Kg/KW Hr.) | Thermal Efficiency (%) |
|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 1500 | 74 | 260 | 0.81 | 0 | 0 | 0 |
| 2 | 5 | 1500 | 54 | 310 | 1.11 | 1.34 | 0.828 | 10.14 |
| 3 | 10 | 1500 | 45 | 340 | 1.33 | 2.7 | 0.492 | 16.32 |
| 4 | 15 | 1500 | 39 | 390 | 1.53 | 4.04 | 0.379 | 21.40 |
| 5 | 20 | 1500 | 33 | 420 | 1.81 | 5.39 | 0.336 | 24.05 |
| 6 | 25 | 1500 | 27 | 450 | 2.21 | 6.74 | 0.328 | 24.71 |

**Table 4: Performance Parameters for Diesel fuel**

| S. No. | Load (Kgf) | Engine Speed (Rpm) | Time (Sec.) | Ex. Temp. (°C) | Fuel Consumption (Kg/Hr.) | Brake Power (KW) | Brake Sp. Fuel Consumption (Kg/KW Hr.) | Thermal Efficiency (%) |
|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 1500 | 69.52 | 270 | 0.85 | 0 | 0 | 0 |
| 2 | 5 | 1500 | 52.9 | 315 | 1.12 | 1.347 | 0.8314 | 9.3 |
| 3 | 10 | 1500 | 42.71 | 360 | 1.39 | 2.695 | 0.519 | 15.7 |
| 4 | 15 | 1500 | 37.31 | 400 | 1.59 | 4.04 | 0.398 | 20.4 |
| 5 | 20 | 1500 | 31.46 | 450 | 1.89 | 5.39 | 0.35 | 23 |
| 6 | 25 | 1500 | 25.87 | 470 | 2.30 | 6.738 | 0.34 | 23.6 |

**Table 5: Performance Parameters for 10% blending fuel**

| S. No. | Load (Kgf) | Engine Speed (Rpm) | Time (Sec.) | Ex. Temp. (°C) | Fuel Consumption (Kg/Hr.) | Brake Power (KW) | Brake Sp. Fuel Consumption (Kg/KW Hr.) | Thermal Efficiency (%) |
|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 1500 | 67.80 | 275 | 0.87 | 0 | 0 | 0 |
| 2 | 5 | 1500 | 48.4 | 320 | 1.23 | 1.347 | 0.91 | 9.26 |
| 3 | 10 | 1500 | 40.23 | 365 | 1.48 | 2.695 | 0.549 | 15.4 |
| 4 | 15 | 1500 | 34.23 | 410 | 1.74 | 4.04 | 0.43 | 19.64 |
| 5 | 20 | 1500 | 28.67 | 460 | 2.07 | 5.39 | 0.384 | 21.8 |
| 6 | 25 | 1500 | 23.53 | 475 | 2.53 | 6.738 | 0.375 | 22.51 |

**Table 6: Performance Parameters for 20% blending fuel**

| S. No. | Load (Kgf) | Engine Speed (Rpm) | Time (Sec.) | Ex. Temp. (°C) | Fuel Consumption (Kg/Hr.) | Brake Power (KW) | Brake Sp. Fuel Consumption (Kg/KW Hr.) | Thermal Efficiency (%) |
|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 1500 | 65.33 | 280 | 0.91 | 0 | 0 | 0 |
| 2 | 5 | 1500 | 46.6 | 330 | 1.287 | 1.347 | 0.95 | 8.92 |
| 3 | 10 | 1500 | 38.10 | 375 | 1.56 | 2.695 | 0.57 | 14.72 |
| 4 | 15 | 1500 | 32.05 | 420 | 1.83 | 4.04 | 0.45 | 18.82 |
| 5 | 20 | 1500 | 27.78 | 465 | 2.14 | 5.39 | 0.39 | 21.41 |
| 6 | 25 | 1500 | 22.69 | 490 | 2.62 | 6.738 | 0.38 | 21.91 |

**Table 7: Performance Parameters for 30% blending fuel**

| S. No. | Load | CO | HC | $NO_X$ |
|---|---|---|---|---|
| 1 | 0 | 22 | 0.01 | 3 |
| 2 | 5 | 18 | 0.05 | 3 |
| 3 | 10 | 13 | 0.1 | 4 |
| 4 | 15 | 11 | 0.17 | 7 |
| 5 | 20 | 8 | 0.22 | 15 |
| 6 | 25 | 6 | 1.6 | 38 |

**Table 8: Emission characteristics at different load for Diesel fuel**

| S. No. | Load | CO | HC | $NO_X$ |
|---|---|---|---|---|
| 1 | 0 | 19 | 0.01 | 4 |
| 2 | 5 | 17 | 0.06 | 5 |
| 3 | 10 | 11 | 0.11 | 7 |
| 4 | 15 | 9 | 0.18 | 11 |
| 5 | 20 | 7 | 0.24 | 17 |
| 6 | 25 | 5 | 1.8 | 40 |

**Table 9: Emission characteristics at different load for 10% blending fuel**

| S. No. | Load | CO | HC | $NO_X$ |
|---|---|---|---|---|
| 1 | 0 | 18 | 0.05 | 6 |
| 2 | 5 | 15 | 0.09 | 8 |
| 3 | 10 | 11 | 0.15 | 12 |
| 4 | 15 | 9 | 0.21 | 19 |
| 5 | 20 | 7 | 0.28 | 27 |
| 6 | 25 | 5 | 2.3 | 43 |

**Table 10: Emission characteristics at different load for 20% blending fuel**

| S. No. | Load | CO | HC | $NO_X$ |
|---|---|---|---|---|
| 1 | 0 | 16 | 0.07 | 9 |
| 2 | 5 | 14 | 0.12 | 11 |
| 3 | 10 | 7 | 0.18 | 16 |
| 4 | 15 | 5 | 0.23 | 20 |
| 5 | 20 | 4 | 0.31 | 32 |
| 6 | 25 | 2 | 2.9 | 48 |

**Table 10: Emission characteristics at different load for 30% blending fuel**

## 2. Results and Discussion

### Performance characteristics

### Break thermal efficiency v/s Brake power

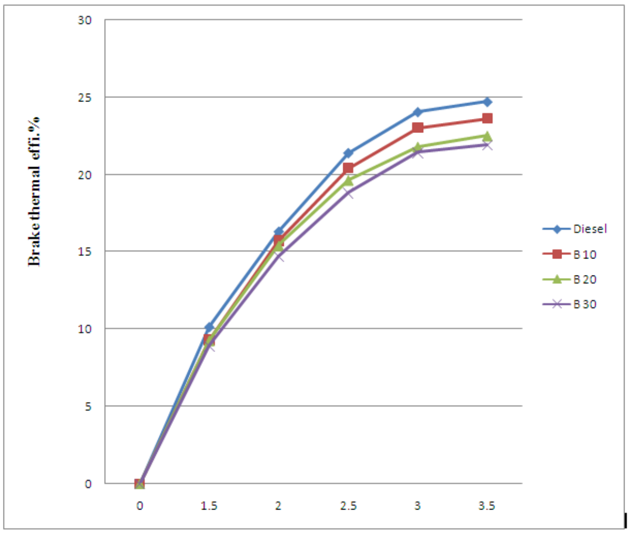



**Fig 2 Brake thermal efficiency for blending fuels at different power**

Figure shows that the thermal efficiency of all fuel blends. The brake thermal efficiency is based on the brake power of the engine. This efficiency gives an idea of the output generated by the engine with respect to heat supplied in the form of fuel. At the maximum load, brake thermal efficiencies were obtained to be 28%, 27.5%, 26.53%, 25.6%, 24% and 23% for BB 10, BB 20, BB 30, BB 60, BB 80, BB 100 respectively, which were nearer to diesel (29%). Transesterification process reduces the dual fuel viscosity and increases the volatility. This enhances the fuel atomization and better fuel combustion delivering improved thermal efficiency. Break thermal efficiency in case of blending 10% is highest in comparison to 20% blending, 30% blending and pure diesel. We get optimum value in case of 10% blending.

**Brake specific Fuel Consumption V/S Brake Power**

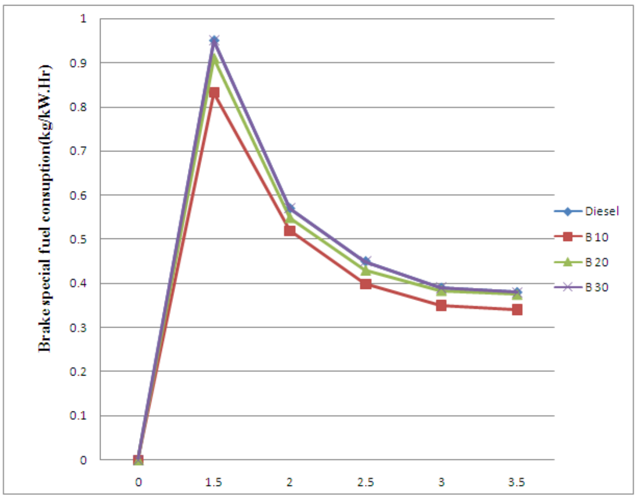



**Fig 3: Brake special fuel consumption for blending fuels at different power**

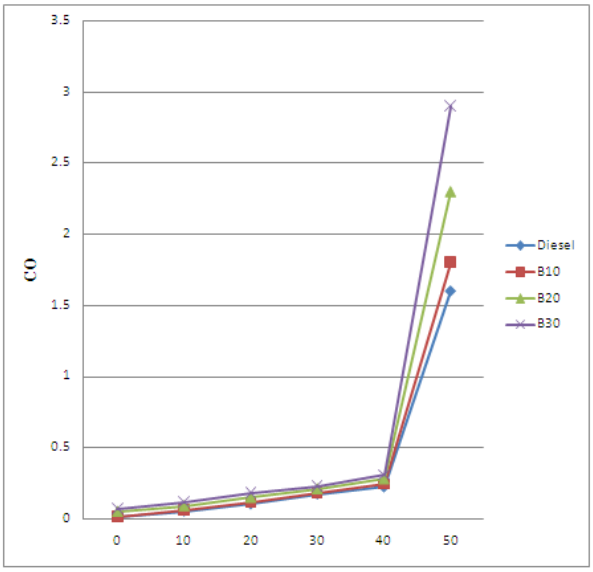



**Fig 4: CO Emission for blending fuels at different load**

## 3. CONCLUSIONS

1) This paper investigates the performance of the engine with dual alternate fuels. The performance and emissions tests were conducted with diesel, and blends of caster, mustard seed oil and diesel at different loads and constant speed (1500 rpm).
2) On the whole it is seen that operation of the engine is smooth on BB 10, BB 20, BB 40, BB 60, BB 80 and BB 100. From the experimental results obtained, Compared to neat diesel operation, dual biodiesel of caster and mustard seed oil results in comparable engine performance and slightly higher emissions.
3) All the dual biodiesel tested result in a slightly lower thermal efficiency and increased smoke, and CO levels.
4) India being an agricultural country, the energy from bio sectors will be highly beneficial for both plantation as well as transportation. Thus caster and mustard seed biodiesel blended dual biodiesel will be a highly beneficial fuel in terms of both economy as well as fuel Independence because this caster and mustard seed will be easily available as long as air and water are available in the earth. The results show that, dual blended biodiesel will be a good substitute and it could replace diesel in future.
5) As the above graphs shows that 10% blending gives us optimum values of performance and emission characteristics
6) Blends have lower value of Co, Unburned hydrocarbon than diesel. This is due to better combustion of fuel inside the cylinder than diesel.
7) The Brake thermal efficiency, brake specific fuel consumption of blends is lower and higher (except 10% blending) respectively than diesel, this is due to higher viscosity and lower calorific value of the fuel.
8) The properties like density, viscosity ,flash point of blends is higher and calorific value is almost 0.8 to 0.9 times that of diesel

## REFERENCES

[1] Altin, Recep, Selim Cetinkaya and Huseyin Serdar Yucesu, 2001. "The potential of using vegetable oil fuels as fuel for diesel engines", Energy Conversion and Management 42, pp 529-538

[ 2] Altiparmak, D., Deskin, A., Koca, A., Guru, M. 2007. Alternative fuel properties of all oil fatty acid methyl ester-diesel fuel blends. Bioresource Technology 98:241–6.

[3] Canakci M. and Van Gerpen, J.H. 2001. Comparison of engine performance and emission for petroleum diesel fuel, yellow grease biodiesel, and soybean oil biodiesel. ASAE Annual International Meeting. Paper No. 016050.

[4] Capareda, S. 2007.Biodiesel and Industrial Products from Oils. 4th Short Course Texas A&M University College Station, TX.

[5] Cetinkaya M, Ulusay Y, Tekı`n Y, Karaosmanoglu F. 2005. Engine and winter road test performances of used cooking oil originated biodiesel. Energy Conversion Management 46:1279–91.

[6] Kean, A.J., Sawyer, R.F., Hartley, R.A. 2000. A fuel-based assessment of off-road diesel engine emissions. J. of Air & Waste Management Association 50:1929-1939.

[7] Lapuerta, M., Armas, O., Rodriguez-Fernandez, J. 2007.Effect of bio diesel fuels on diesel engine emissions. Progress in Energy and Combustion Science 10.1016.

[8] Munoz, M., Moreno, F., Morea, J. 2004. Emissions of an automobile diesel engine fueled with sunflower methyl ester. Transactions of the ASAE 47(1): 5-11.

[9] Monyem, A. and J.H. Van Gerpen. 2001. The effect of biodiesel oxidation on engine performance and emissions. Biomass Energy 20:317-325.

[10] NBB. (2006a) Biodiesel Basics. Jefferson City, MO: National Biodiesel Board. Available at: www.biodiesel.org.Accessed 9 March 2006.

[11] Pramanik, K., 2003. "Properties and use of jatropha curcas oil and diesel fuel blends in compression ignition engine", Renewable Energy 28, pp 239–248.

[12] Piazza, J. 2007. Feedstock economics: A comparison of feed stocks. Biodiesel and Industrial Products from Oils. 4th Short Course. Texas A&M University. College Station, TX.

[13] Senthil Kumar M, Jaikumar M. A comprehensive study on performance, emission and combustion behaviour of a compression ignition engine fuelled with WCO (waste cooking oil) emulsion as fuel. Journal of the Energy Institute 2014; 87(3):263-271.

[14] US energy information administration, US Department of energy, March 2013

[15] Usta, N. 2005. An experimental study on performance and exhaust emissions of a diesel engine fuelled with tobacco seed oil methyl ester. Energy Conversion Management 46:2373–86.

[16] Yucesu, H.S. and C. Ilkilic. 2006. Effect of cotton seed oil methyl ester on the performance and exhaust emission of a diesel engine. Energy Sources Part A 28:389 – 98.

[17] Zhou, Adrian, and Elspeth Thomson, 2009. "The development of bio fuels in Asia", Applied Energy 86, pp S11–S20.